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# Social mapping of perceived ecosystem services supply – The role of social landscape metrics and social hotspots for integrated ecosystem services assessment, landscape planning and management

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ABSTRACT

This paper contributes to the discussion on integrating societal considerations, stakeholders' perceptions and laymen knowledge into ecosystem services (ES) assessments. The paper illustrates how social mapping of perceived ES supply (or alternatively demand) can contribute to integrated ES assessment. Based on sketched locations of the, according to 38 respondents, most important ES at the local scale, we describe the perceived ES distribution with social landscape metrics (abundance, diversity, richness, risk, rarity) based on traditional landscape ecology indicators. We illustrate how social landscape metrics can inform ES management and planning and describe how synergies between ES as stated by the respondents differ from calculated synergies (the latter based on correlation coefficients between perceived ES abundance). We present indicators pointing to locations where (multiple) ES synergies are perceived by stakeholders (stated synergy index), and to conflicting ES and ES perceived to be at risk (risk index). Overlapping social ES hotspots based on the social landscape metrics with ES hotspots based on more traditional biophysical modelling (biophysical hotspots) and ecological inventories (ecological hotspots) results in social–ecological or social–biophysical hotspots, coldspots and warmspots relevant for nature and landscape planning, management and governance. Based on an analysis of the overlaps between social, biophysical and ecological hotspots on the one hand, and the contribution of ecological quality, land zoning categories and conservation statuses on the other hand, we discuss the added value of integrating social ES mapping in integrated ES assessment, above ES assessments based on biophysical or ecological attributes. Given the limited overlap between social hotspots and ecological or biophysical hotspots, we conclude that integrating stakeholders' mapping of perceived ES supply (or demand) into ES assessments is necessary to reflect the societal aspects of ES in ES assessments. However, with a limited sample of respondents, there is a risk of collectivisation of respondents' viewpoints as a common, societal stance. Moreover, the social landscape metrics are not suitable for describing the distribution of ES with low perceived abundance. Finally, we explain how social ES assessment can result in mainstreaming ES in planning, policy and practice.



## 1. Introduction

Mapping ecosystem services (ES) supply is traditionally based on land use and land cover data, or on the spatial distribution of biophysical or abiotic assets and flows (Chan et al., 2012; Fagerholm et al., 2012; Martínez-Harms and Balvanera, 2012; Menzel and Teng, 2009; Plieninger et al., 2013; van Riper et al., 2012). Reviews by Crossman et al. (2013) and Egoh et al. (2012) indicate such approaches focus on ES more easily quantifiable, thereby missing out intangible ES (such as learning opportunities or aesthetics) provided by ecosystems. Menzie et al. (2012) warn against "ecosystem service myopia" occurring when one chooses to focus on one or a few ES over others, probably resulting in missing important trade-offs among services.

A participatory mapping approach can overcome methodological difficulties in mapping intangible ES, and widen the range of ES

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included in the assessment. Moreover, participatory mapping exercises answer the call to involve stakeholders early and explicitly in ES assessment (Cowling et al., 2008; Menzel and Teng, 2009). We argue participatory mapping can complement more traditional ES mapping approaches, thereby broadening as well the scope of ES included, as the knowledge base (expert, local and lay knowledge). Whereas participatory mapping can include objective (e.g. citizen science-based species distribution or mapping footways used for recreation) and/or subjective data (e.g. perceived landscape quality or the location of intangible ES), we define social mapping as mapping subjective perceptions, the personal use of nature and landscape and intangible ES (see also description of key terms in Table 1). In this manuscript we will focus on social mapping of subjectively perceived ES supply. ES mapping by both experts and laymen in integrated ES assessments can assist landscape planning and ES governance in better complying with users' and beneficiaries' perceptions and expectations (Fagerholm et al., 2012; Menzel and Teng, 2009), and thus conflicts on land use and land management can be prevented (Gunderson et al., 2004; Zhu et al., 2010).

With the growing attention towards cultural ES, a need for alternative approaches for mapping intangible ES and/or perceived ES delivery emerged. Participatory mapping is considered mainly suitable for mapping cultural ES and provisioning ES, that are not unidirectionally linked to land use, land cover, or biophysical characteristics of the landscape (e.g. Bryan et al., 2010; Palomo et al., 2013; Martínez-Harms and Balvanera, 2012; Plieninger et al., 2013). We refer to a review by Brown and Fagerholm (2015) on the use of PGIS (participatory GIS) and PPGIS (public participation GIS) for an overview of technical aspects of participatory mapping of ES (such as selection of ES to be mapped, sampling strategies, methods for mapping and analysing, scale, geographic scope, accuracy, data quality, etc.). Next to a ES-oriented approach in the literature, other terms have been used for describing values perceived by stakeholders, such as social values (Bryan et al., 2011; Sherrouse et al., 2011), community values (Martínez-Harms and Balvanera, 2012), and landscape values (Raymond and Brown, 2006; Zhu et al., 2010).

There is a need for indicators that summarise and describe the distribution of participatory mapped ES, as a first step to spatially

**Table 1**
Description of key terms.

| Term | Definition |
|---|---|
| Biophysical ES assessment | Assessment of ecosystem services supply based on biophysical data sources (mapping, modelling, remote sensing, surveying). This includes ES delivery modelled on land use, land cover or vegetation type (Cowling et al., 2008; Fontaine et al., 2013) |
| Biophysical hotspot | Site or area where ES delivery (provisioning or regulating) is significantly higher than average in the study area (in our study based on the local Getis-Ord Gi* statistic) (Alessa et al., 2008; Donovan et al., 2009) |
| Coldspot | Site or area where a variable (in our case ES delivery, or a social landscape metric) is significantly lower than average in the study area (based on for example the local Getis-Ord Gi* statistic) (Alessa et al., 2008; van Riper et al., 2012) |
| Ecological (or biological) hotspot | Site or area where ecological or biodiversity value is significantly higher than average in the study area. The ecological or biodiversity value can be based on species mapping or habitat surveying, summarised e.g. using landscape ecology indicators (diversity, abundance, etc.) (Brown et al., 2004). We applied local Getis-Ord Gi* for defining ecological hotspots |
| Economic ES assessment | Assessment of the economic value of ES in the study area. This is most frequently in the form of monetary valuation, but also non-monetary quantitative valuation is possible (Cowling et al., 2008; Fontaine et al., 2013) |
| Hotspot | Site or area where the value is significantly higher than average in the study area. The delineation of the hotspot can be based on the local Getis-Ord Gi* statistic (Fagerholm and Käyhkö, 2009), on kernel densities (Brown and Pullar, 2012), on expert (Brown et al., 2004) or layman evaluation or on landscape ecology indicators (diversity, abundance, etc.) (Brown and Reed, 2012; Plieninger et al., 2013) |
| Integrated ES assessment | Assessment of ES supply and/or demand based, integrating social, biophysical and economic ES assessment through e.g. multi-criteria analysis (MCA) or deliberative approaches (Boeraeve et al., 2015; Fontaine et al., 2013) |
| Local Getis-Ord Gi* statistic | Identifies where high or low values tend to cluster, compared to random distributions. The output of the Gi* statistic is a *z*-score for each grid cell (Fagerholm and Käyhkö, 2009; Zhu et al., 2010). The Gi* characteristic is calculated as (Getis and Ord, 1992): $G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}(d)x_j}{\sum_{j=1}^{n} x_j}$ with $\{w_{i,j}\}$ a symmetric spatial weight matrix ($w_{i,j}$ being 1 for cells within distance $d$ of cell $i$, and 0 for all other grid cells), $x_j$ is the value associated with cell $j$ |
| Participatory mapping | A mapping exercise by non-experts and/or stakeholders. This can be done through interviews, focus groups, online, deliberative meetings, etc. As well one-to-one interactions as group work is possible. Participatory mapping can include objective data (e.g. species distribution or actual land use, i.c. local and/or layman knowledge) as well as subjective data (e.g. perceptions, intangible ES or desired land use) |
| Perceived ES distribution | The distribution of ES in the study area, as described by social landscape metrics, based on respondents' sketched locations of perceived ES supply |
| Perceived ES supply | The locations of ES delivery (or alternatively demand) in the study area as perceived by the involved stakeholders |
| Social hotspot | Site or area where the perceived ES distribution (ES supply or ES demand) is significantly higher than average in the study area (based on the local Getis-Ord Gi* statistic). The perceived ES distribution can be described with social landscape metrics (Alessa et al., 2008; Whitehead et al., 2014) |
| Social landscape metrics (SLM) | Generic term for indicators traditionally applied in landscape ecology, but increasingly used as aggregation indices in participatory mapping (including participatory mapping of ES). These include e.g. diversity, abundance, and richness. See Table 3 for on overview of selected social landscape metrics (Brown and Reed, 2012; Bryan et al., 2010; Fagerholm et al., 2012; Plieninger et al., 2013) |
| Social mapping | A specific type of participatory mapping by non-experts and/or stakeholders, whereby instead of objective or expert data, more subjective data such as respondents' perceptions or perceived intangible ES supply are mapped. |
| *z*-Score | A statistical measurement that indicates if, and how strong, the value is diverging from the mean. The *z*-score represents the statistical significance of clustering identified by the Gi* statistic. A high positive *z*-score ($z > 1.96$) indicates a hotspot (at significance level 0.05), a low negative *z*-score ($< -1.96$) indicates a coldspot (Fagerholm and Käyhkö, 2009; Zhu et al., 2010) |